Optimization of Drive System for a Cable Climbing Device

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Client: University of Saskatchewan Space Design Team
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The University of Saskatchewan Space Design Team requires a functional, adaptable, and efficient drive system for their prototype climber. The climber is designed to compete in the 2008 NASA Elevator 2010 Power Beaming Competition. A detailed design, optimization, and analysis was conducted in order to meet the following objectives and constraints.

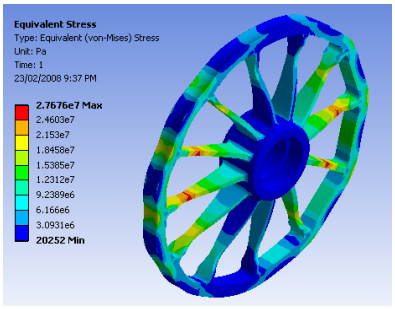
Design Objectives

- Complete drive system ready for manufacturing
- Build prototype as a proof of concept
- Develop 3D CAD model
- Perform finite element analysis on all parts
- Optimize materials
- Perform detailed cost estimate

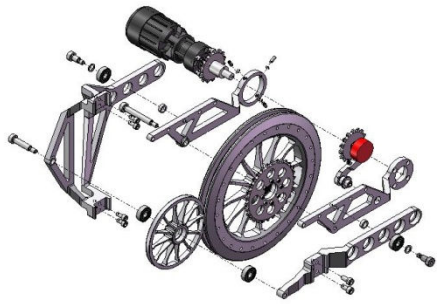
Design Constraints

- Minimal rolling resistance and friction
- Capable of climbing a 6.35 mm diameter cable
- Capable of climbing a distance of 1 km at 5 m/s
- Unaffected by variations in cable tension
- Facilitate ease of maintenance and modification
- Can be mounted by two people within 10 minutes

Capitalizing on the successes and improving on the deficiencies of the 2007 design was a constant goal and major strategy throughout the design process. Many design alternatives were considered before the final concept was selected. Adaptive pinching was selected as the proposed design based on a value analysis selection procedure. Based on this approach, a proof of concept was built to optimize geometry, verify performance, and test materials. From this, a 3D CAD model was created and finite element analysis was performed to maximize strength and minimize weight.

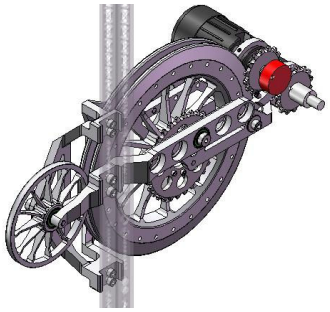


Finite element analysis of idler sheave


Exploded view of drive system

The adaptive pinching drive system acts like a pivoting cam, automatically adjusting the normal force exerted on the cable based on climber weight. By doing this, the normal force can be maintained at a level slightly higher than what is required to keep the climber from slipping down the cable. The range of normal force applied by the cam can also be adjusted to account for a slippery or wet cable surface. Because the normal force can be precision tuned, rolling resistance is reduced to a minimum further increasing climber efficiency.

Once assembled, the drive system can be mounted quickly by swinging the cam in and out of place, no hardware to remove or parts to fumble with. 6061-T6 aluminum was selected for the custom machined components based on its extremely high strength to weight ratio and excellent machinability. The estimated mass of the proposed drive system is 3 kg. The total cost of the drive system, assuming components are machined at Engineering Shops and including material costs, is estimated to be $1,100.


Overview of cable climbing drive system